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Water pricing towards sustainability of water resources: a case study in Beijing

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Abstract: The role of water pricing for managing water resources is widely recognized in many areas of the world because of the increasing scarcity of water resources, a high competition between water uses and environmental degradation. Based on the analysis of cost of water, this paper explores which types of cost should be reflected in the water pricing enhancing the sustainability of water resources. The principle of full cost pricing in which the cost should include supply cost, opportunity cost and externalities is proposed as a means to achieve the sustainability of water resources. In a case study of Beijing, low water price is analyzed as one reason for unsustainable water consumption. Thus water pricing justified is necessary and pressing. It is proposed to justify water price in phased manner and eventually towards full cost pricing. The assessment of impacts on water resources by raising water price shows water pricing could alleviate the conflict between water supply and demand. This paper concludes that water pricing can play an effective role in enhancing the sustainability of water resources in Beijing.

Keywords: water resources; water price; cost; full cost pricing; sustainability; Beijing

Introduction

During the latter half of this century the pressure on natural water resources in many regions of the world has been increasing dramatically because of the population growing and expansion of economic activities. A close look at the state of water resources to date reveals that the sustainability of the water system is at stake in many areas of the world. Many factors can be found behind this situation, among these, water pricing does not give the "right" signal for using water in a sustainable manner. It is increasingly recognized that water pricing could improve use efficiency and conservation thereby improving both quantitative and qualitative state of water resources. The interesting question is what kind of water pricing precept could achieve the aim of sustainability of water resources.

China is the biggest developing country in the world with a large population and fast economic growth in recent years. Water scarcity in China is not in doubt: at least 400 of the largest 600 cities face water shortages, and population that continues to grow in size and affluence will place an enormous burden on water supply. Water pricing reform has been recommended by both academic and policy analysts as one of the main solutions for easing water scarcity. Thus, the study of water pricing under this situation should be significant and useful for water pricing reform.

1 The theory of water as an economic good

The conceptual framework of treating water as an economic good is comprised of two components: the value of water and the cost of water. The interaction of these two components contributes to the foundation which the realistic pricing of water resources is based on.

1.1 The value of water

Water has a value to users, who are willing to pay for it. Like any other good, consumers will use water so long as the benefits from use of an additional cubic meter exceed the costs so incurred. The value of water to a user is the maximum amount the user would be willing to pay for the use of the resource. For normal economic goods which are exchanged between buyers and sellers under a specified set of conditions, this value can theoretically be measured by estimating the area under the demand curve. Since markets for water either typically do not exist or are highly imperfect, it is not simple to determine what this value is for different users of water(Briscoe, 1996). There are numerous studies that attempt to compute the marginal value of water use by different sectors, mainly in agriculture, industry and domestic use. In general, the value of water for many low-value crops is very low, but for high-value crops is relatively high. The value

for household purpose and industrial purpose is a similar order of magnitude and is usually much higher than the value for most irrigated crops (Briscoe, 1996; Stephen, 1998).

1.2 The cost of water

In thinking about the cost of water, it is necessary to know that there are three different types of costs incurred in providing water to a household, a field or an industry. The first cost is that of constructing and operating the infrastructure necessary for storing, treating and distributing the water. It is supply cost. The second cost is the opportunity cost incurred when one uses water and, therefore, affects the use of the resource by another user. The third cost is the externalities. As a fugitive resource, water results in pervasive externalities. These costs are discussed in the following section.

Supply cost: Full supply costs are composed of two separate items: operation and maintenance (O&M) cost, and capital cost. O&M cost are associated with the daily running of the supply system. Capital costs include capital consumption (depreciation charges) and interest costs associated with reservoirs, treatment plants, conveyance and distribution systems(Rogers, 1997). There are two kinds of accounting methods to calculate this cost which are historical cost pricing and replacement cost pricing respectively. Historical cost pricing is using the historical cost to measure the value of goods. It is a backward accounting stance. Replacement cost pricing is using replacement cost to measure the value of goods. It is a forward looking accounting stance and look for the costs associated with replacement of the capital stock with increasing marginal cost supplies. Marginal cost denotes the extra or additional cost of producing another unit of output. The cost of raw water is almost always rising since the closest, cheapest sources are those that are used first. Thus the marginal costs of water are greater than average costs (Briscoe, 1996).

Opportunity cost: In economics, opportunity cost is defined as the value of the best available alternative(Rogers, 1997). Opportunity cost addresses the fact that by consuming water, the user is depriving another user of the water. If that other user has a higher value for the water, then there are some opportunity costs experienced by society due to this mis-allocation of resources. The opportunity cost of water is zero only when there is no alternative use; that is no shortage of water. Ignoring the opportunity cost undervalues water, leads to failures to invest, and causes serious mis-allocations of the resource between users.

Externalities: Water resources exhibit externalities in the sense that they have the property of "mutually interfering usage" (Briscoe, 1997). Individuals take the valuable commodity of clean water from the same environment that they then use to dump wastes, thus interfering with the use of no-longer-clean water by themselves and others. In economic parlance these aspects are referred to as externalities. The most common externalities are those associated

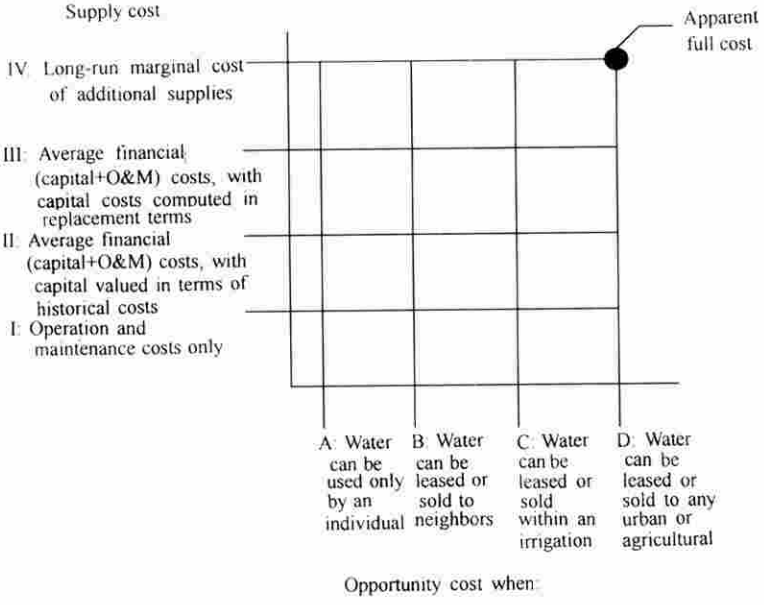

Fig.1 Schematic representation of the definition of use cost and opportunity cost(Briscoe, 1996)

with the impact of an upstream diversion of water or the release of pollution on downstream users. There are also externalities due to over-extraction from or contamination of common pool resources such as lakes and underground water.

Full cost of water: The overall cost of water is the sum of supply cost, opportunity cost and externalities. In order to ensure that users take the full cost of using water into account, it is useful to combine these three components of cost. In order to illustrate clearly, we only combine the supply cost and the opportunity cost at first which is illustrated schematically in Fig. 1. Then on this basis, externalities are combined (note: it is simplified that only the negative externalities are considered). It is schematically shown in Fig. 2.

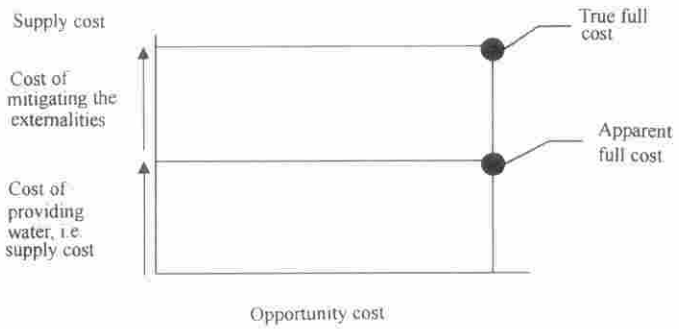

Fig. 2 Full cost with negative externalities

2 Water pricing towards sustainability of water resources

Water pricing has effective impacts on water uses. However, which types of cost should be reflected in the pricing precept is crucial in terms of the sustainability of water resources.

2.1 Marginal cost pricing

The central policy prescription of microeconomics is the equation of price and marginal cost. Marginal cost is the cost of producing one more unit, or the added cost of incremental output. There are two types of marginal cost, which are short-run and long-run marginal costs. In the short-run, the capital stock is fixed and its cost is a fixed cost. In the long-run capital is variable and its cost constitutes variable cost. Short-run marginal cost is always less than long-run marginal cost. Long-run marginal cost pricing could be more close to reflect the true cost than short-run marginal cost pricing.

Water price based on marginal cost pricing precepts are intended to provide price signal that result in a more efficient allocation and use of a scare supply of water. By setting price equal to marginal cost, consumers are able to compare the benefit of additional consumption with its associated cost and make efficient choices. In this way, production may be guided towards more efficient levels.

However, if production does not take proper account of the full social and environmental costs, marginal cost will be too low and the price based on marginal cost can not promote effectively the efficiency of water uses and conservation. Thus it will result in the sustainability of water resources at stake.

2.2 Full cost pricing

While it is known that water pricing could improve use efficiency and conservation thereby enhance the sustainability of water resources, it is crucial to decide which types of cost need to be reflected in water price that can play an effective role in enhancing the sustainability of water resources.

In thinking about the sustainable development in economic terms, "sustainable development can be understood so that sustainable development is development that pays its full cost during the process of development" (Panayotou, 1994). Meanwhile, the Commission of the European Communities (CEC) has proposed that water pricing needs to reflect different cost types (CEC, 2000): (1) financial costs of water services or supply cost, that include the costs of providing and administering these services. They include all operation and maintenance costs, and capital costs; (2) resource costs or opportunity cost, that represent the cost of forgone opportunities which other uses suffer due to the depletion of the resource

beyond its natural rate of recharge or recovery; (3) environmental costs or externalities, that represent the costs of damage that water supply and uses impose on the environment and ecosystem.

Based on these, it is proposed that full cost (including supply costs, opportunity costs and environmental costs) pricing is the means to achieve the sustainability of water resources.

Full cost pricing is thought to bridge the gap between private and social costs by internalizing all external costs (both depletion and pollution costs) to their sources: the producers and consumers of the resource depleting and polluting commodities (water in this case). Full cost pricing is going to charge not only the production cost but also full scarcity cost for resource depletion and full damage cost for environmental degradation(Panayotou, 1994).

3 Case study in Beijing

3.1 Water resources in Beijing

Beijing is the capital of China. It is the political and economic center of China with an area of 16800 km^2. In 1998, the population was 12.46 million. During the past several years, Beijing has achieved its success in economic modernization and development. However, this economic growth hinges on the wide-scale and unremitting exploitation of natural resources. On the one hand, the water demand is increasing because of the population growth and the development of industry and agriculture. On the other hand, the degradation and depletion of water resources, often by industrial or agricultural waste or emissions, reduces its overall availability. Both growing demand and declining supply are contributing to the situation of serious water shortages that Beijing has faced.

In Beijing, the average annual precipitation is 606 mm, and total amount of rainfall is 9.996 billion m^3 (BCM). The available water resources per capita in Beijing is 353 m^3, 289 m^3, and 241 m^3 at reliability of 50%, 75% and 90% respectively which is much lower than the average level in the world (Ministry of Water Resources of China, 1999). In a typical year, Beijing is short 300 – 500 million m^3 of water, and it compensates for these shortages by over-extracting groundwater. Beijing Water Resources Bureau has predicted that Beijing will suffer water shortage of 0.444 BCM in 2000 and 2.221 BCM in 2020 at reliability of 50% *.

3.2 Water price in Beijing

Water prices have been justified several times during this decade, but they are usually lower than the cost of production. For example, the surface water for irrigation is only charged 0.02 RMB Yuan/m^3, which is almost free. Even the average price of surface water is 0.29 RMB Yuan/m^3 but is still lower than the cost of production(Sun, 2000). For tap water, the cost of tap water supply was 0.469 RMB Yuan/m^3, the average price was 0.42 RMB Yuan/m^3 in 1994. At present, the tap water price for residents is 1.3 RMB Yuan/m^3 which is still lower than the cost of supply of 1.32 RMB Yuan/m^3(Sun, 2000). Since the water price is lower than the cost, Beijing municipality has to subsidize the water utility every year.

Such low water price could not promote the consumer to conserve water and use efficiently. It is estimated that the current end-use efficiency of fresh water is around 10%. In agriculture, almost half of water for irrigation either evaporates or leaks. In industry, the water efficiency is 75% lower than the developed countries. The low water price also leads the agriculture and industry have no incentive to invest in water saving technology. The awareness of citizens to conserve water is also low because of the low water price.

3.3 The need to take action

The present low water price has impeded the sustainable water resources development and usage. Since the water price is too low, the revenue from water charge can not cover the costs of production. As a result, water suppliers can not maintain the normal operation and development, water projects is aging

* Beijing Water Resources Bureau, 1997. Water resources present situation and future situation prediction in Beijing

because of the lack of money to repair and manage, and water services suppliers can not supply reliable services. On the other hand, the low water price can not pass on a right signal to water users for water conservation and use efficiency. Large amount water is wasted and over used which result in large quantity of wastewater. In addition, the low water price results in the low water recycle because of the cost of reprocessing water is more expensive than the subsidized fresh water. Both of the over consumption of water and discharge of large quantity of wastewater put a high pressure on the water environment which threats the sustainability of water resources. It leads to water scarcity and environment pollution even more severe. Therefore, it is the time that the low water price has to be justified without other choices.

3.4 Proposed water pricing justified

According to the above description, it is known that the present water price in Beijing is lower than the cost of supply. However, even if the water pricing based fully on cost of production is still not enough. Because water pricing based on the cost of production do not include the opportunity cost and environmental externalities. According to the above discussion, water pricing which could enhance the sustainability of water resources should be full cost pricing, in which the supply cost, opportunity cost and environmental externalities are all included. It is proposed that water pricing could be justified in a phased manner to ensure acceptability and stability. Phased implementation gives users time to adjust to new conditions and thereby minimise the burden on any affected group. It also increases the predictability of that system for both users and suppliers. Thus phased implementation of full cost pricing can be schemed in which first step could be average production cost pricing with capital valued in terms of historical costs and the second step could be average production cost pricing with capital costs computed in replacement terms. The third step could be long-run marginal production cost pricing. The final goal is full cost pricing, in which supply cost, opportunity cost and environmental externalities are all included. These steps are schematically illustrated in Fig. 3.

3.5 Assessment of impacts on water resources by raising water price

If water pricing will be justified according to above proposed steps, it is interesting to see the impacts on the water resources even if only the first step is achieved which means water price is set based on average production cost pricing with capital valued in terms of historical costs.

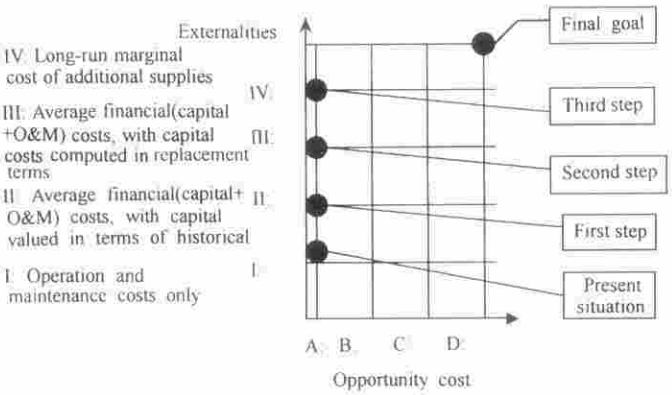

Fig.3 Schematic representation of proposed steps for water pricing justified

When water is treated as an commodity, it is available to adopt the following formula to calculate the quantity of water demand under different water price (James, 1984).

$$Q_2 = Q_1 \times (P_1/P_2)^E.$$

Where Q_2 is the quantity of water consumption at raised water price P_2, Q_1 is the quantity of water consumption at original water price P_1. E is the price elasticity of demand.

In a Beijing municipal report, it has calculated that water price based on average production cost with capital valued in terms of historical costs is 0.68 RMB Yuan for surface water and 2.08 RMB Yuan for tap water*. Because of the limitation of data, here only residential and industry water use are calculated.

* Beijing Water Resources Bureau, 1999. General planning of capital's sustainable utilization of water resources in early 21st century

In 1998, the quantity of residential water use was 1.084 billion m^3 in Beijing(Guo, 2000). The water price was 1.0 RMB Yuan. The price elasticity of demand is −0.24(Shen, 2000). The quantity of industry water use was 0.986 billion m^3 in Beijing(Guo, 2000). Among this, tap water occupied 0.295 billion m^3. The remaining was surface water and ground water. The tap water price for industry use was 1.3 RMB Yuan. The price of surface water and ground water for industry use was 0.36 RMB Yuan. The price elasticity of water in industry use is −1.03(Huang, 1999). By using these data to above formula, the total water saved for both residential water use and industry use is 0.621 billion m^3. This amount of water saved is more than the predicted water shortage of 0.444 billion m^3 at reliability of 50% in 2000. Therefore, using water price as a tool to mitigate the conflict between water demand and water supply is effective.

4 Conclusions

The role of water pricing for managing water resources is widely recognized in many areas of the world. This recognition relates to the increasing scarcity of water resources, a high competition between water uses, and problems of environmental degradation. Water pricing can contribute to higher water use efficiency thus a lower pressure on water resources and on the environment thereby more sustainable consumption of water.

When water is treated as an economic good, the cost of water constitutes not only the supply cost but also the opportunity cost and environmental externalities as well. It is crucial to take the opportunity cost and environmental externalities into consideration since they are invisible financial cost comparing with the supply cost. Therefore, full cost pricing is proposed as a sustainable way in water pricing since it take all costs including supply cost, opportunity cost and environmental externalities incurred during water supply into account.

Artificially low water price in Beijing leads to water over consumption and large quantity of wastewater discharge, which result in high pressure on the water environment. In order to develop and utilize water resources sustainably, justifying water pricing in Beijing is necessary and pressing. It is proposed that water pricing could be justified in a phased manner and eventually towards the full cost pricing. The assessment of impacts on water resources by raising water price shows that water pricing could be an effective tool for more sustainable water consumption.

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